THE HYPOTHETICAL AUDITORY TRACT IN THE LIGHT OF RECENT ANATOMICAL OBSERVATIONS.*

By GRÆME M. HAMMOND, M.D.,

PHYSICIAN TO THE DEPARTMENT FOR NERVOUS DISEASES IN THE METROPOLITAN THROAT HOSPITAL.

AT a meeting of the New York Neurological Society, held on February 1st, of this year, I read a paper describing and giving the measurements of certain gigantic nerve cells discovered by myself, and showing by comparison that these cells were larger, as far as carnivora were concerned, than any of the giant cells described by Betz in his communication entitled "An Anatomical Description of Two Brain Centres," which appeared in the *Centralblatt* of 1874.

In this article Betz claims that the cells discovered by him are larger than the cells of any other region of the central nervous system.

In making this statement its author does not seem to have borne in mind that the existence of as large and larger cells has already been established. While the statement would, therefore, be inaccurate as applied to man, it is demonstrably erroneous as applied to the lower animals, on whose brains his researches were first made; for here it can be shown that other cells, in lower centres, are decidedly larger than those of the so-called "cortical nests."

---

* Read in outline before the American Neurological Association, June 16, 1881.

From the brain of the same cat in which I discovered the giant cells before mentioned, I prepared some 150 sections from a larger number cut transversely to the cerebral axis, and embracing that portion of the brain included between the lower olivary altitude and the optic lobes of the corpora quadrigemina.

These sections enabled me to make a thorough study and examination of the cells contained in the optic lobes, nucleus tegmenti, and auditory nucleus. These cells are not a new discovery. They were known to Meynert, and their dimensions in the human brain have been given by him, but no one that I am aware of has given the comparative measurements of these cells.

I think it preferable in giving the comparative measurements of cells and their nuclei of different centres, to draw my deductions from measurements made of the cells contained in different centres of the same brain rather than to compare the measurements of different centres of different brains. I therefore propose in the present paper, to give the measurements and descriptions of cells of the optic lobes, nucleus tegmenti, and the auditory nucleus, from sections taken from the same brain, and also to compare them with the cells of the cortical group discovered by myself.

Let us occcupy ourselves first with the consideration of the large multipolar cells of the optic lobes of the corpora quadrigemina.

The optic lobes differ anatomically from the post-optic lobes, or nates, chiefly in the fact that they possess a true cortical structure. Looking below the peripheral layer into the deeper structure of the optic lobes, a group of giant cells can be seen of about the same size and shape as those known to Betz. They resemble very closely the large multipolar cells found in the lumbar enlargement of the spinal cord. Their outlines are very distinct and their numerous processes plainly visible. Many of these cells appear circular in the sections, but this is probably due to their being obliquely cut, or to imperfect staining. In their long diameter they measure from .03 mm. to .10 mm., and transversly from .02 mm. to .07 mm. Their nuclei measuring from .01 mm. to .025 mm. in diameter.

These cells are not found in nests. The largest cells do not always possess the largest nuclei; in fact, there seems to be no rule governing the size of the nucleus in proportion to the size of the cell; for a very large cell may be seen to be provided with one of the smallest nuclei, and a small cell may possess a nucleus whose circumference almost equals that of the cell itself.

The cells presented for observation in the following woodcut, fig. 1, are specimens of cells from the optic lobes of the corpora quadrigemina of the cat. Although the cell shown in the centre of the illustration is a large one, its long diameter, exclusive of processes, measuring about .08 mm., it possesses one of the smallest nuclei. The processes in this cell are plainly visible. Let us now proceed to describe the cells of the nucleus tegmenti: a large nucleus situated in the same altitude as the optic lobes, and about midway between the central tubular gray and the ganglion of Söemmering. Here we find giant cells, circular and ovoid in form, with a central round nucleolated nucleus. They are densely settled, but are not arranged in any regular order. They possess from one to six visible processes. The ovoid cells measure from .07 mm. to .12 mm. in their long diameter, and from .03 mm. to .05 mm. transversely.

The circular cells measure from .04 mm. to .08 mm. in diameter. The nuclei of both varieties measure about .025 mm. in diameter. In fig. 2, a representation of both varieties of these cells is given. The words ovoid and circular refer to the cells apparently devoid of processes.

The cells discovered by myself were found in sections taken from the brain of the same cat from which the sections illustrating the cells of the optic lobes and nucleus tegmenti were made. These cells, unlike the two last mentioned, were found in the true cortical structure in the first primary arched gyrus, anterior to the fissure of Sylvius. They were found in both hemispheres, but only to a slight extent in the right one. In size they measured from .05 mm. to .12 mm. in length, and from .04 mm. to .06 in width, with a central, round, nucleolated nucleus measuring about .03 mm. in diameter.

These cells, when compared to the cells found in the optic lobes and nucleus tegmenti, present marked similarities in many respects. Regarding their dimensions to the dimensions of their nuclei they are nearly identical; and, though many of the cells of the optic lobes resemble somewhat the appearance of the multipolar cells of the lumbar enlargement of the spinal cord, yet, when groups of the three varieties are compounded together, it may be seen that each variety is nearly a reproduction of the other.

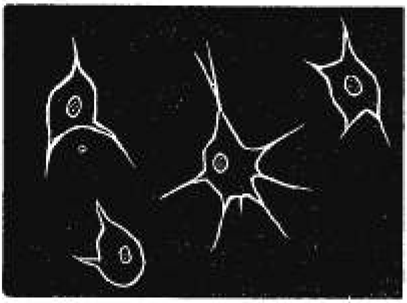

FIG. 1.

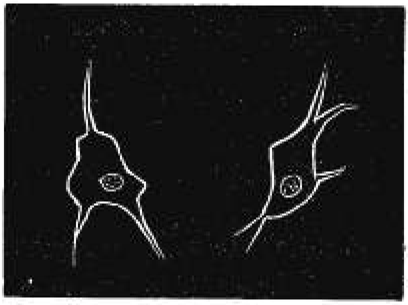

FIG. 2.

Since reading my paper describing the new cells in the cat's brain, I have pursued my investigations farther, and examined the cortical structure of the human brain about that area supposed to correspond to the point where I located the cells found in the cat's brain.

From about sixty or seventy sections made from both hemispheres, I was enabled to find five or six sections containing cells in every respect identical with those discovered in the cat's brain, though somewhat smaller and less numerous.

It is my purpose, by comparing the descriptions and measurements of the new cortical cells with the cells of the auditory nucleus and the other cells of the auditory tract, to show that the cells I discovered are presumably related to hearing, and to advance the theory that the cortical auditory centre is composed of a group of cells identical in form and structure with the cells of the auditory nucleus and tract, and that it is situated in the gyrus angularis, above the horizontal branch of the fissure of Sylvius, and at a distance from its posterior extremity equal to about one-fourth of its length.

A confirmation of this theory has been presented by Dr. A. B. Ball, in the *Archives of Medicine*, April, 1881, in which, in his article on "A Contribution to the Study of Aphasia," he mentions the phenomena of "word-deafness," resulting from a spot of cerebral softening involving that portion of the cortex situated above and at the posterior extremity of the fissure of Sylvius. Although the "centre" discovered by myself was located about 18 mm. anterior to the spot of cerebral softening shown in the illustration in Dr. Ball's article, yet their proximity is not without certain points of interest, for either the area containing the cells may have been more extensive than I supposed, or it is possible that the cells of that region, being deeply seated, may have undergone softening without that fact having been observed at the autopsy.

The destruction of the cortical auditory area would not obstruct the hearing, but it would render it impossible to convert the impression received into a logical conception of the sound heard. Dr. Ball, speaking of his patient, says: "Early in his illness, on my remarking to him one day, 'Dr. Peters called to see you,' he replied, 'I don't know him.' The name was repeated several times, but he failed to recognize it, although it was the name of an intimate friend. The written name was then shown him. 'What a fool I am,' he exclaimed, 'of course I know him.' This was the first instance in which my attention was drawn to the fact that certain auditory impressions failed to be converted into concepts, although the conceptive faculty remained intact."

I can hardly agree with Dr. Ball in his statement "that the conceptive faculty remained intact," for, had such been the case a logical conception would have followed the auditory impression; on the contrary, when the name was mentioned he did not recognize the sound of it. But when the written name was presented before him, the impression was optical and was transmitted as such to the cortical optical centre for *per*ception.

The fact that he could read and identify the name with the object showed that *so far and no further* the conception of Dr. Peters had not suffered. But insomuch as *per*ceptions are the necessary basis for *con*ceptions, it cannot be said that the patient's conceptional sphere was free, as the auditory perceptions were absent.

Quoting from Dr. Ball, the patient again says: "The words I can't pronounce are the words I can't *hear*," showing that only the impressions of a limited number of sounds failed to produce correct conceptions. This proves, to my mind, that either the cortical auditory "centre" was only involved in the process of softening to a slight degree, or that only a part of the "centre" came within the range of the area of softening. I am rather inclined to the latter view.

Anatomically it is well established that after abutment of the auditory nerve root in the auditory nucleus, the auditory tract chiefly takes a course to the nucleus dentatus in the cerebellum, from thence through the brachium conjunctivum, and thence to the nucleus tegmenti. From this point the auditory tract is imperfectly traced, but it is clear that either through the lowest medullary laminæ of the thalamus, or through the posterior part of the internal capsule, it is continued to the cortex.

As far as I can glean from Flechsig's[1] great monograph, the fibres of this region can be traced to the vicinity of the posterior end of the fissure of Sylvius. This theory was in part anticipated by Meynert [2] and confirmed by Mendell, these authors tracing the tract as far as the nucleus tegmenti by chiefly anatomical methods. A further confirmation was offered by Spitzka,[3] who identified the nucleus tegmenti in those reptiles possessing large cells in the auditory nucleus, and who notes that throughout the animal range the cells of the nucleus tegmenti and the special division of the auditory nucleus seemed to keep step in development.

The cells of the auditory nucleus are larger and their processes more boldly marked than any of the other varieties I have described in this paper, yet in their general characteristics they are similar to those cells found in the other groups. They measure from .07 mm. to .15 mm. in length, and from .04 mm. to .09 mm. in width, the nuclei measuring about .03 mm. in diameter.

While I would hesitate to commit myself to the view that resemblance in size and shape of nerve cells necessarily involves similarity of function, yet it must be admitted that there is a certain parallelism between the cells connected with special nerve tracts. In this respect I need but instance the close resemblance existing between the giant cells of Betz and the cells of the lumbar enlargement of the spinal cord.

---

[1] Forel. Unterschungen über die Haubenregion. *Archiv fuer Psychiatrie*, vii. Spitzka. JOURNAL OF NERVOUS AND MENTAL DISEASE, 1880.

[2] Th. Meynert. Vom Gehirn der Saugethiere. Stricker's Handbuch.

[3] Spitzka. Further notes on the brain of the Iguana and other Sauropsida.

From this point of view the general similarity between the elements of the large-celled division of the auditory nucleus, of the nucleus tegmenti, and of the cortical nest described, lends support to the view that they are stations upon one tract. But a still stronger support is to be found in the fact that the size and development of the auditory nucleus, the nucleus tegmenti, and the cortical nest keep step, in the animal range, within certain limits, and as far as ascertained; that is, where the large-celled division of the auditory nucleus is largest the nucleus tegmenti is most massive and the cortical nest most numerous in cells.

This theory is in part confirmed by the report of a case of "Congenital Atrophy of the Brain," which appeared in the paper of Rohon.[1] Here, though the mass of brain substance was diminished to a remarkable extent, there was no atrophy of the auditory nucleus, of the nucleus dentatus, nor of the nucleus tegmenti.

As we ascend in the scale we find this progress greater in the cortical area than in the nucleus tegmenti, and greater in the latter, in turn, than in the auditory nucleus.

This presents a certain resemblance to three other cell groups,—those related to the innervation of muscles of animal life. Here the lowest group, that is, the multipolar cells of the anterior horns of the spinal gray, are presumably presided over by the multipolar cells of the tegmentum, and these in turn by the giant cells of Betz.

---

[1] Rohon. Untersuchung über ein Microcephalen-Gehirn, *Wien*, 1879.

These three groups of cells follow the same laws of progress that have already been cited for the sensory cells; that is, where there is an increase in the number of cells in the lowest group there is also an increase in the higher ones, and this increase in the higher group is greater in proportion to that in the lower; for example, just as there is progress in the development of cells in the anterior spinal cornu in the frog as contrasted with the proteans, so there is a still greater increase in the cells in the reticular field in lower mammalia as contrasted with the reptiles and amphibians, and a still more rapid stride in the higher mammalia over the lower, in whom these cell groups are really absent.

This anatomical fact is in parallelism with the physiological observation that the simple reflex acts are the common property of all animals, high and low; that progress in function is first manifested in the development of coördinate reflexes, which, in their turn, are merely stepping-stones for the highest nervous combinations of psychical life.